Engaging the Community

Strategies for Software Assurance Curricula Outreach

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Abstract. How to better achieve secure and correctly functioning software systems, regardless of their origins, application domain, or operational environments? Engaging a knowledgeable team of educators to develop curricula, courses, and other materials for the discipline of software assurance is but the start. If we build it, will they come? In this paper, I explore strategies this team of educators used to encourage the community of computing educators to adopt software assurance curricula.

Background

Our lives and our world depend on software. Highly complex, interdependent software systems are critical to virtually every aspect and domain of society today. However ubiquitous software has become, security advances have not been commensurate with the vital role software now plays. As a consequence, our exposure to risk is ever increasing.

The complexity of software and software-intensive systems has inherent risk: it obscures the essential intent of the software, masks potentially harmful uses, precludes exhaustive testing, and also introduces additional problems with respect to the operation and maintenance of the software. The interdependence of these systems means attackers can focus on the most vulnerable component to damage the larger system(s), while today's interconnectivity makes the proliferation of malware easy, but the identification of its source difficult [1]. Threats are large and diverse, from unsophisticated opportunists to technically savvy entities backed by organized crime [2], nation states, and similar organizations with malicious intent.

Software Assurance Curriculum Project

Understanding the importance of the software assurance discipline for protecting national infrastructures and systems, the DHS National Cyber Security Division has recognized the growing need for skilled practitioners in this area. At the direction of DHS, researchers in SEI[1] at Carnegie Mellon University developed the Software Assurance Curriculum Project (SwACP). The SwACP development team is composed of knowledgeable educators from a number of institutions of higher education,[2] who collectively have substantial background in software assurance research, software engineering research and practice, and software engineering education [3], and who participate in related professional society curricula development.

What is software assurance? The definition used by the SwACP team is, "Software assurance (SwA) is the application of technologies and processes to achieve a required level of confidence that software systems and services function in the intended manner, are free from accidental or intentional vulnerabilities, provide security capabilities appropriate to the threat environment, and recover from intrusions and failures [4]." [3] This is a slight extension of the Committee on National Security Systems' definition [5] used by our DHS sponsor.

Many colleges and universities have degree programs in areas such as software engineering and information security, but programs and tracks in software assurance are lacking. The work of the SwACP addresses this gap.

The focus of the SwACP is to:
- Identify a core body of knowledge that educational institutions can use to develop Master of Software Assurance (MSwA) degree programs
- Mentor universities in developing standalone MSwA degree programs and tracks within existing software engineering and computer science master's degree programs
- Promote an undergraduate curriculum specialization for software assurance
- Address community college needs

To date the SwACP team has produced four volumes[4]:
- Master of Software Assurance Reference Curriculum[5] [4]
- Undergraduate Course Outlines[6] [6]
- Master of Software Assurance Course Syllabi [7]
- Community College Education[7] [8]

In addition to these reports, the team also developed papers [1, 3, 9,10, 11], presentations [12,13], and workshops [14]. [8]

Both the Association for Computing Machinery (ACM) and the IEEE Computer Society (IEEE-CS) have recognized the MSwA Reference Curriculum as appropriate for a master's program in software assurance. This formal recognition signifies to the educational community that the MSwA Reference Curriculum is suitable for creating graduate programs or tracks in software assurance.[9]

Outreach

Defining transition strategies for future implementation of the software assurance curricula is one of the goals of the SwACP. Many SwACP team members had been previously involved in curriculum work and understood the need to have a comprehensive plan for promoting the transition and adoption of the various curricula. In the academic world, transition is a lengthy process, with a number of potential barriers to adoption. While introducing one new elective course may be relatively easy, introducing a new track takes significant effort, and adding a new degree program is a real challenge. Many barriers exist: insufficient interested students in the surrounding geographic area,

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14. ABSTRACT
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lack of qualified faculty, lack of administrative support, funding, etc. For the SwACP to succeed, a comprehensive outreach and promotional plan was needed.

For the first volume produced, the MSwA Reference Curriculum, planned promotional activities targeting educators included [3]:

• Publicity—SwACP team members disseminated announcements, press releases, and flyers regarding the team's work via email, websites, educational publications, and professional societies; they also distributed promotional materials to colleagues when they attended conferences.

• Software assurance education discussion group—We established a LinkedIn discussion group in which faculty interested in implementing all or portions of the curriculum could interact with the team and other colleagues who are using the curriculum.

• Awareness—Team members conducted and videotaped[10] an awareness-raising faculty workshop at the Conference on Software Engineering Education and Training (CSEET) 2010 [14]. This workshop was among the various presentations given at faculty and curriculum development venues. Additionally an overview podcast was produced, including a discussion of what students and employers can expect.[11]

• Mentoring—The SwACP team is mentoring universities and faculty members who wish to offer a course, track, or MSwA degree program. This support includes review of implementation plans and course outlines and advice on references and other materials.

• Publication—SwACP team members have written papers and given talks on the curriculum.

• Professional society recognition—As mentioned previously, both ACM and IEEE-CS officially recognize the MSwA curriculum.

For transition and promotion of the MSwA Reference Curriculum, early adoption is important. The Stevens Institute of Technology, home of one of the SwACP team members, was the first school to adopt elements of the curriculum: it has developed two tracks in software assurance within its Master of Science in Software Engineering program. One track is for students who anticipate a career in secure software development, while the other is for students interested in acquisition and management of trusted software systems. For those students who already have an advanced degree or who are not ready to commit to a full graduate program, graduate certificates are available [3].[12] Consideration and plans for adoption of courses and tracks are underway at the universities of the team members, as well as other schools.

Outreach: Leverage and Trust

For the MSwA curriculum transition and promotion goal, all planned activities were successfully completed and continue to be pursued. Long term, a key point of leverage is the continued participation by SwACP team members in reviewing and updating professional society curriculum guidelines. For example, SwACP team member Mark Ardis is the chair of the

Software Engineering 2004 Review Task Force, a joint effort of the ACM and the IEEE-CS. This task force has collected comments from the software engineering community about the need to update Software Engineering 2004, the recommended guidelines for undergraduate software engineering education. Ardis noted that several reviewers had commented on the need for more material on software security and assurance. SwACP team member Elizabeth Hawthorne is chair of the ACM Committee for Computing Education in Community Colleges and is also a member of the ACM delegation to the Steering Committee of the joint ACM and IEEE-CS Computing Curriculum: Computer Science 2013,[13] an effort in its planning stages focused on international curricular guidelines for undergraduate programs in computing. She reported that one new knowledge area under consideration is dedicated to "computer security" (called Information Assurance and Security).[14] Through these relationships, the SwACP team can stay updated and engaged with current curricula development efforts and seek ways to leverage the curricula the team developed in graduate, undergraduate, and community college programs.

In the short term, the need for quick educational community feedback on draft SwACP documents and for broader awareness and involvement suggested a focused leveraging of trusted, personal relationships, in addition to the promotion and transition mechanisms already cited. Specifically, I was tasked with extending the SwACP team's ongoing efforts to faculty and entities whom I knew to be involved in course, resource, and curriculum development for software engineering, information systems, information assurance, computer science, information security, etc. at the master's, undergraduate, and community college levels. By no means was this complete coverage, but the trusted relationships increased the likelihood that faculty would engage (and redistribute the information). Utilizing relationships with other colleagues, appropriate faculty at, for example, the U.S. Service Academies, were specifically targeted via a trusted intermediary.

Targeted faculty included[15]:

• Past participants in the National Science Foundation (NSF)-funded Information Assurance Capacity Building Program at Carnegie Mellon University

• Principal investigators of the 15 NSF-funded Advanced Technological Education (ATE) Centers and through the NSF ATE program manager to other NSF program managers

• Those at 17 NSA/DHS Centers of Academic Excellence in IA Education (CAE/IA) and CAE-Research (CAE-R) programs[16]

• California State University Discipline Council (department heads of computer science, information science/information systems, and software engineering at the 23 schools that make up the council)

• Participants in the educational outreach and curriculum development activities and members of the NSF Science and Technology Center Team for Research in Ubiquitous Secure Technologies[17]

• Members of the Association of Computer/Information Sciences and Engineering Departments at Minority Institutions[18]

• Members of various faculty email lists, including personal lists of faculty in related disciplines interested in course and curriculum development, and those working on articulation agreements with community colleges

• U.S. service academies and postgraduate schools[19]

Over the years, faculty from these entities formed collaborative relationships to create, adapt, adopt, and share new materials as appropriate for their departments and prospective students, as well as for others. Given their interest in related disciplines, these communities of interest were prime targets for our outreach effort.

In addition to faculty and academic institutions, it was important to leverage related government and practitioner efforts. Collaborating with organizations in the DoD and NIST, the DHS National Cyber Security Division Software Assurance (SwA) Program co-sponsors the Software Assurance Community. In this community, members of government, industry, and academia come together to discuss, develop, and implement software security practices, methodologies, and technologies in forums and working groups.[20] Because of SwACP team member participation in this community, the 15th semi-annual SwA Forum in September 2011 examined the implications of trends and emerging factors in training and education for software assurance workers. The NIST National Initiative for Cybersecurity Education (NICE) has a goal to "bolster formal cybersecurity education programs encompassing kindergarten through 12th grade, higher education and vocational programs."[21] At the December 2011 DHS Working Group meeting, co-chaired by the SwACP team lead, Nancy Mead, the alignment with NICE was discussed.

Outreach Outcomes

From the beginning, the SwACP recognized the importance of transition strategies for the implementation of the software assurance curricula, including the ongoing promotion of the curriculum work and outreach to the various communities of interest to encourage them to participate. Given the time constraints, the various educational levels addressed, and potential constituencies involved, multiple people and entities employed multiple outreach mechanisms, coordinating where possible with related efforts.

Challenges to our outreach effort include the usual potential barriers to adoption of courses, tracks, and curricula, including the time and resources needed, especially in light of sometimes-severe funding cuts in departments. Another challenge was the alignment and timing regarding revision cycles of both departmental and the related professional curriculum development efforts.

Outreach mechanisms that are proving effective include:

• The Build Security In website, sponsored by DHS, and the SEI MSwA website

• Ongoing SwACP team member participation (previously and currently) with professional curricula development activities

• Papers and presentations at appropriate educator conferences and workshops

• Leveraging trusted relationships with educators in related

disciplines to increase the likelihood of engagement and dissemination (to other interested faculty) of information related to SwA curricula and content.

One example of successfully leveraging trusted relationships with educators is the Department of Computer Science at the U.S. Air Force Academy. They recently undertook a curriculum review that defined multiple cross-curricular initiatives to support program outcomes, including "secure programming" (security and software assurance) [15]. Among the resources used was the Undergraduate Course Outlines [6]. They are also considering the development of some undergraduate course exercises and projects that focus on secure coding and software assurance, to be incorporated into existing undergraduate courses as a means to integrate these topics as "natural and normal practices inherent to software development."[22]

Faculty and educators have contacted the SwACP team lead for information about how to build a BS or MS program with an SwA concentration.[23] One department at the University of Houston has adopted significant portions of the software assurance curriculum in their program by incorporating elements in several courses, where appropriate, with the majority in focus courses (two each in the undergraduate and graduate programs).[24]

Other outreach mechanisms are early in their respective cycles or require more of a critical mass to be effective. For example, the Software Assurance Education discussion group on LinkedIn provides a forum for faculty to share problems and experiences in teaching software assurance courses. As more educators incorporate software assurance topics, modules, and courses into their departmental programs, we hope they will utilize this forum. Ongoing participation in the related government and practitioner efforts will help with the alignment and leveraging of these activities, with the common goal to increase awareness, participation, and adoption of appropriate software assurance practices.

Summary

The SwACP team feels that software assurance education at all levels is essential to ensure that software and software-intensive systems are developed with assurance in mind [11]. While software assurance supports and complements the educational objectives of a software engineering program, it also supports and complements the educational objectives of related disciplines such as computer science and information systems. Engaging knowledgeable educators experienced in related curriculum development to produce software assurance curricula and related materials is but one part of this DHS-funded effort. Multiple mechanisms must be continually utilized to reach the various educator communities to increase awareness, encourage participation, and ultimately adopt software assurance topics, courses, tracks, and curricula. Certain outreach strategies have proved to be successful in the relatively short time the SwACP has been in existence. Leveraging professional curricula development entities, as well as alignment with related government efforts, while longer term, should provide the foundation for sustainment.◈

Disclaimer:

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NOTES

1. The Software Engineering Institute is a federally funded research and development center sponsored by the U.S. Department of Defense and operated by Carnegie Mellon University.

2. In addition to educators in the SEI, collaborators include educators from Embry-Riddle Aeronautical University, Monmouth University, Stevens Institute of Technology, University of Detroit Mercy, Union County College, and University of Arkansas, Little Rock.

3. Note that computing capabilities may be acquired through services as well as new development. Recovery is an important capability for organizational continuity and survival.

4. These volumes, plus related information and faculty resources, can be found at <www.cert.org/mswa/> and the DHS Build Security In (BSI) website <https://buildsecurityin.us-cert.gov/bsi/>.

5. The Reference Curriculum addresses topics such as assurance across life cycles, risk management, assurance assessment, assurance management, system security assurance, assured software analytics, and system operational assurance. This can be implemented as a standalone program, or as a track within an existing master's program, such as a Master of Software Engineering program.

6. This set of outlines includes seven course descriptions that could be included in a software assurance specialization track of a traditional computer science degree program. To provide an emphasis on software assurance topics in the first year of a curriculum, descriptions of alternative forms of Computer Science I and II are included.

7. The ACM Committee for Computing Education in Community Colleges (<www.acmcccecc.org>), led by Elizabeth Hawthorne, partnered with the SwACP to produce this volume that includes discussion of existing curricula related to software security that are suitable for community colleges. The target audiences are students planning to transfer to a four-year program and students with prior undergraduate technical degrees who wish to become more specialized in software assurance. The report includes course outlines and identification of resources.

8. These are just a few of the papers and presentations. Reference [1] provides the best overview of the SwACP, while reference [11] provides a much briefer synopsis, including those artifacts, foundational materials, and recent curriculum guidelines referenced in the development of the SwACP curricula.

9. The ACM and its partner, the IEEE-CS, have developed several computing curricula and are community leaders in curricula development.

10. The CSEET 2010 three hour workshop is available at <https://www.vte.cert.org/vteweb/RequestAccess/ClassPreview.aspx?Classid=120>

11. Podcast is available at <http://www.cert.org/podcast/show/20101026mead.html>.

12. The environment that allowed SIT to quickly create its software assurance program, as well as potential adaptations of the MSwA curriculum for information systems curricula are also described in [3].

13. <www.cs2013.org>

14. A recent addition to the SwACP, Remzi Seker, University of Arkansas, Little Rock, is a member of the IEEE-CS delegation.

15. In addition to those targeted by other team members and means, this outreach effort included faculty and educational institutions granting master's, bachelor's, and associates' degrees in 21 states and the District of Columbia.

16. <http://www.nsa.gov/ia/academic_outreach/nat_cae/index.shtml>

17. <http://www.truststc.org/>

18. <http://www.admiusa.org/>

19. U.S. Air Force Academy, U.S. Military Academy, U.S. Naval Academy, Air Force Institute of Technology, Naval Postgraduate School, U.S. Naval War College, and U.S. Coast Guard Academy

20. Information about SwA Community activities including forums and working groups can be found at <https://buildsecurityin.us-cert.gov/swa/forums.html>; see especially the Workforce Education and Training Working Group.

21. <http://csrc.nist.gov/nice/aboutUs.htm>

22. Communication to Carol Sledge by Dr. Steve Hadfield, Associate Professor and Curriculum Chair, Department of Computer Science, U.S. Air Force Academy

23. These include Hampton University, TRUST, Gunter Air Force Base, Southeast Missouri State University, Cleveland State University, and University of Detroit Mercy.

24. Communication to Nancy Mead by Wm. Arthur Conklin of the Department of Information and Logistics Technology